A system for measuring electric properties of CO_2/brine saturated samples

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Introduction

To determine the saturation level of the CO_2 underground using electric and seismic monitoring, a good understanding of the cross property relationships and how CO_2 will affect them is necessary. A system to measure electrical properties of core samples has therefore been developed and will be coupled to the ultrasonic system of University of Alberta. Joint electric and acoustic measurements performed without disturbing the sample reduce experimental bias but increase technical difficulties. In this contribution, we focus on the preparatory work related to the measurement of electrical properties.

Experimental setup

This electric measurement system consist of eight 314/316L stainless steel electrodes equally spaced around the cylindrical sample allowing acoustic measurements to be made in the axis direction (Fig 1). The stainless steel electrodes are shown to be relatively stable over time (Fig 2).

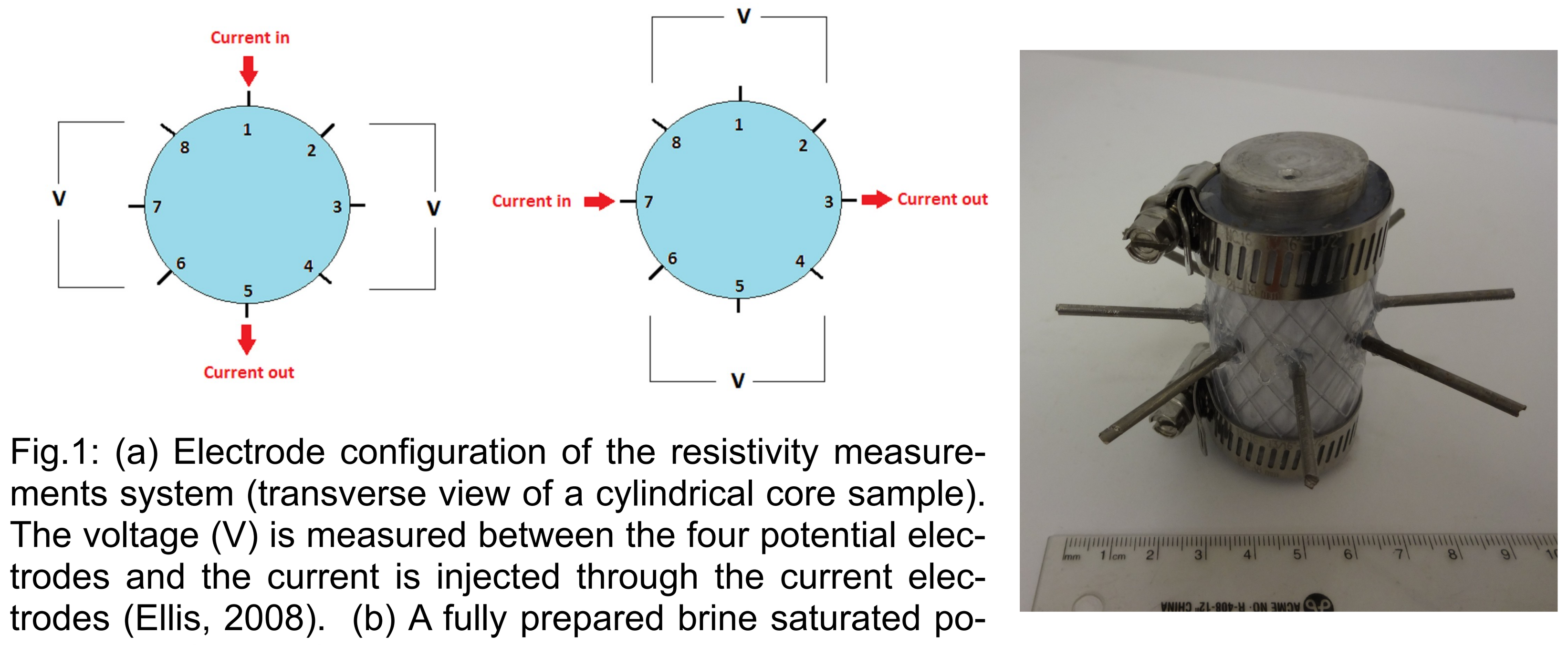

Fig.1: (a) Electrode configuration of the resistivity measurements system (transverse view of a cylindrical core sample). The voltage (V) is measured between the four potential electrodes and the current is injected through the current electrodes (Ellis, 2008). (b) A fully prepared brine saturated porous ceramic sample.

Electrode stability

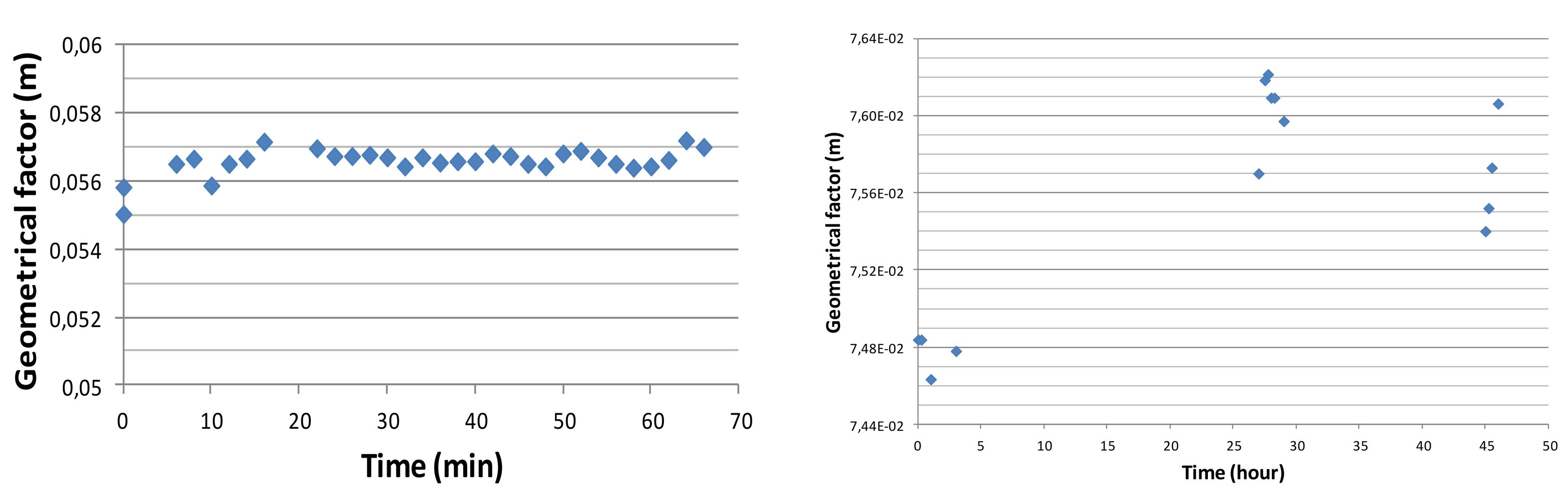

Fig.2 : (a) The geometrical factor measured with a KCl solution of a known conductivity as a function of time. The value seems stable over a one hour period with an error of about 1%.
(b) The geometrical factor measured over a 3 days period. After a day, we notice and increase of 2% associated with a slight corrosion on the electrodes that then remain stable.

Geometrical factor modeling

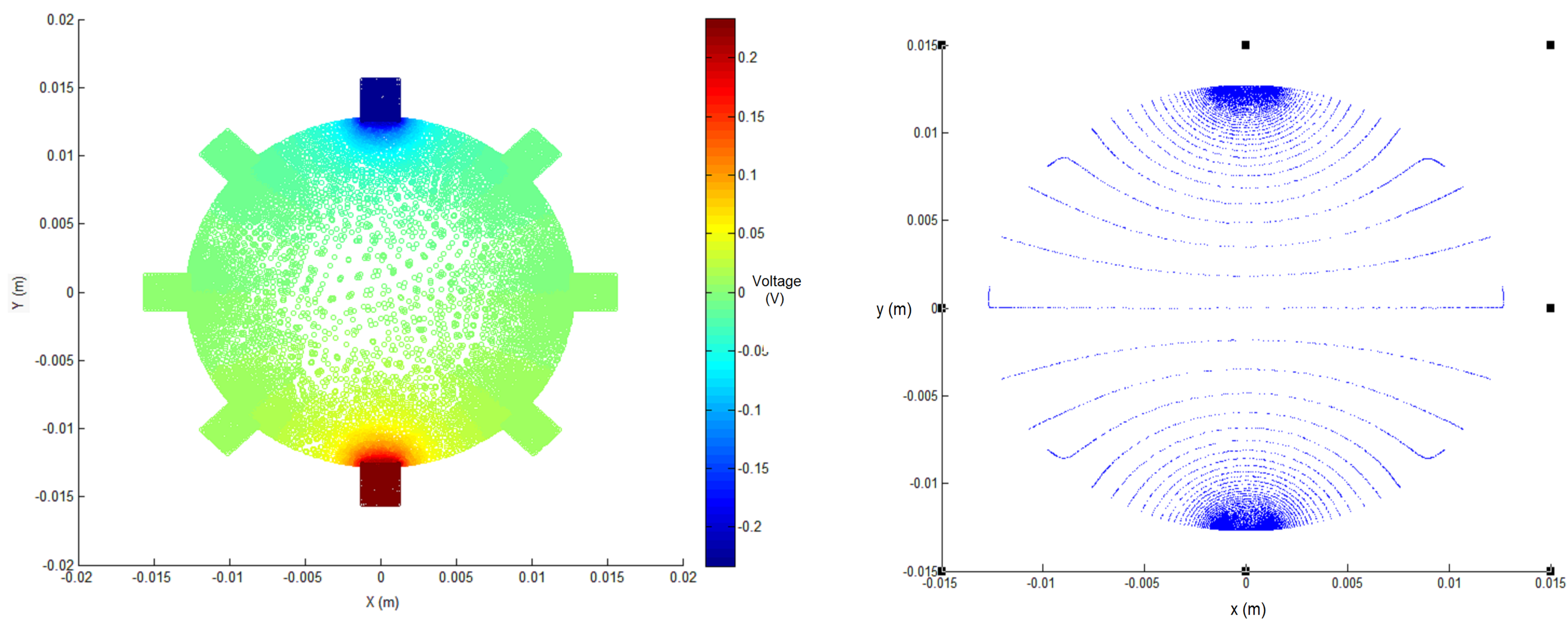

Fig.3 : (a) Electric potential modeled within the sample and the electrodes.
(b) Equipotential lines within the sample. Each level correspond to 1% of the total voltage.

- The resistivity (ρ) is proportional to measured resistance (R) by a geometrical factor (g).

$$\rho = R \cdot g$$

- The geometrical factor depend only on the geometry of the sample and the position of the electrodes. It is determined by modeling the electric potential (therefore R) in the sample for a known resistivity.
- To account for uncertainty on the positioning of the electrodes, the values from the four different pairs of electrodes are averaged which reduces the error on the measurement (Fig 4 and Fig 5).

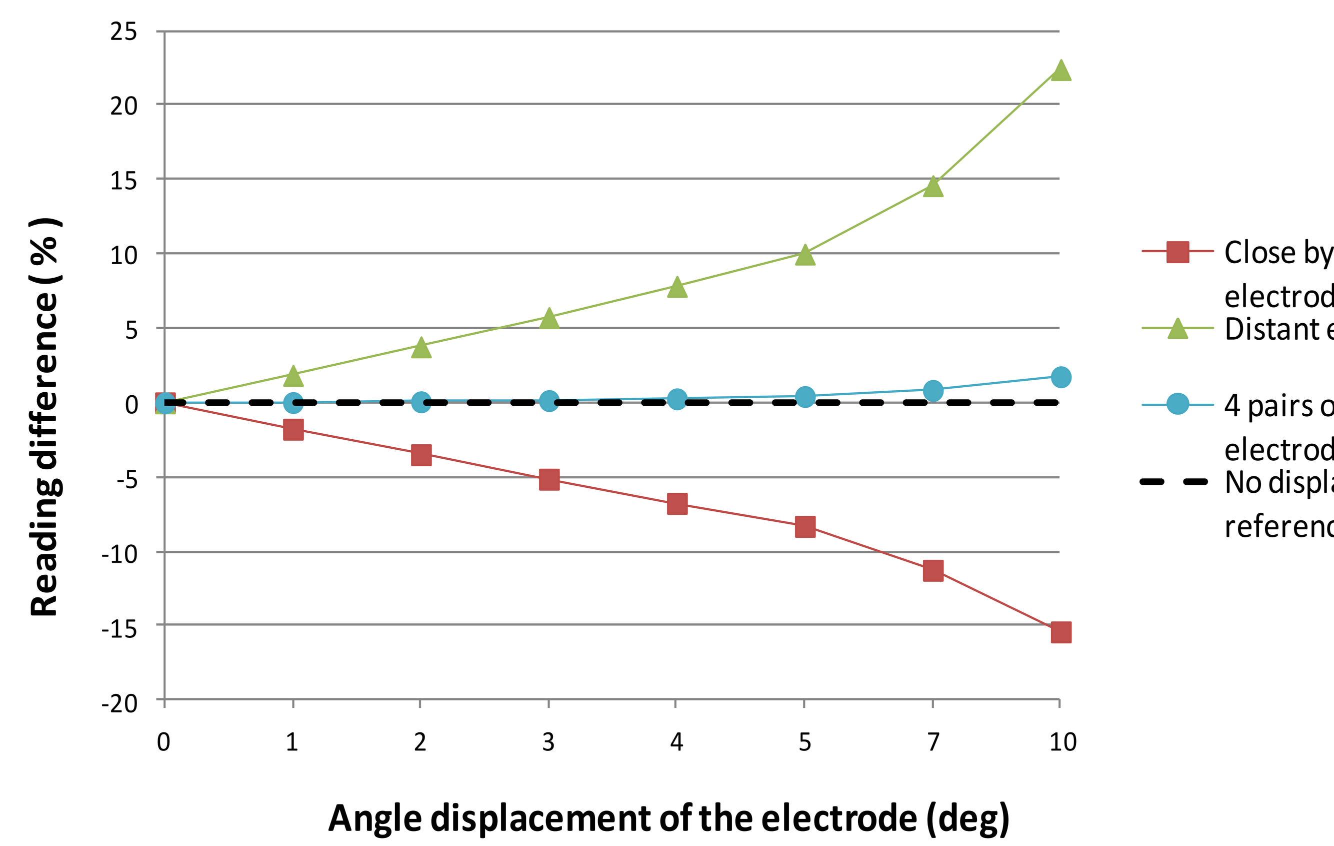

Fig.4 : Modeled difference on the voltage between the pairs of electrodes affected by the angular displacement of one of the four potential electrodes.

Measurements on a ceramic sample

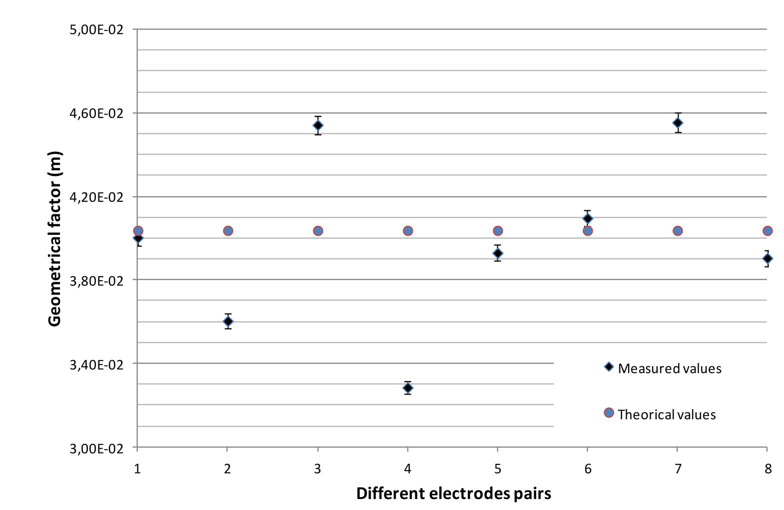

Fig.5 : The geometrical factor for the eight possible electrodes pairs. We observe an important difference with the theorical values. By averaging the different pairs, a mean value of :

$$(3{,}99 \pm 0{,}04) \cdot 10^{-2} \text{ m}$$

is obtained. A difference of about 1% with the theorical value.

Conclusion

- This system allow measuring the formation factor of a isotropic rock sample with a precision close to 2%.
- Its radial configuration frees the two opposed flat surfaces of the core sample which are used to induced acoustic wave through the medium. This way, it should be easy to join it to the acoustic measurement system of University of Alberta.
- The use of stainless steel electrodes offer a good compromise between precision and the solidity. It is critical in order to withstand the high pressures and temperatures of a confinement cell as opposed to non-polarizing Ag/AgCl electrodes which are too fragile (Wang and Gelius, 2009).
- The next step is to implement this system in combination with the acoustic measurement apparatus of University of Alberta and test the system on real core sample rather than porous ceramic samples.

References

Ellis M.H. 2008. *Joint seismic and electrical measurements ofgas hydrates in continental margin sediments.* PhD thesis, University of Southampton.
Wang Z., Gelius L.-J. and Kong F.-N., *Simultaneous core sample measurements of elastic properties and resistivity at reservoir conditions employing a modified triaxial cell—a feasibility study.*. Geophysical Prospecting, 2009, 57, 1009-10026

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